Abstract

Title:

Fabrication and Augmenting of Transition Metal Based Anode and Cathode Composite for High Energy Density Supercapacitor Devices

Improving the energy density of supercapacitors is the primary objective of this research. Supercapacitor electrodes are manufactured using various conducting polymers, metal oxides, sulfides, and carbon-based materials. They have a higher energy density than carbon-based materials due to redox transformations but have a low cycle life due to a sudden volumetric shift when charging and discharging. Therefore, a ternary hybrid system comprised of conducting polymer, metal oxide, and carbon-based material was developed to obtain the advantages of the distinct strategies. Anodic activated porous carbons (APCs) generated from biomass/biowaste materials are proficient candidates for SC applications for their low cost and versatile morphologies with outstanding chemical and mechanical stability. Based on a facile chemical hydrothermal procedure, rGO-Fe_2O_3 and V_2O_5-mwCNT-PANI nanocomposites were fabricated and subjected to various electrochemical tests, exhibiting high specific capacitance values. Nevertheless, the cumulative faradaic output from the novel microwave-assisted MnV_2O_7 hybrid material demonstrated the usefulness of synergy, nanoarchitecture, and surface properties of materials in producing the supercapacitor electrode material. The research on $FeVO_3$ and Ni_4CuO_5-mwCNT yielded both outstanding capacitive and pseudocapacitive outputs. The novel electrodeposited in-situ sulfurize Ni_2FeS_4-Ppy and $Cu_4Co_2Fe_2S_4$ were characterized as outstanding mixed metal sulfides when the composition was altered from a monometallic oxide to a ternary sulfide, resulting in superior specific capacitance and commendable response in high energy and power density. Interpolation of conducting polymer polypyrrole enlarged the working voltage window and exhibited a high-power density. Using the ionic liquid gel polymer electrolyte, a pouch cell is assembled of an activated porous carbon-based symmetric supercapacitor device and Ni_2FeS_4-Ppy and $Cu_4Co_2Fe_2S_4$ based asymmetric supercapacitor devices with operating windows of 4 V and 4.3 V respectively. These electrode materials are indispensable for creating flexible, lightweight, asymmetric supercapacitor cells (ASC). These nanostructured, high-performance, material-based ASC devices can conduit the breach between conventional capacitors and batteries. The Symmetrical supercapacitor cell based on APCs shows specific energy and power, with 878 Wh/kg and 91% long-cycle retention. Furthermore, the assembled asymmetric supercapacitor has a remarkably higher specific energy of 757 Wh/kg and 96% long-cycle retention. This constructed ASC device possesses a specific capacity of 352 mAh/g, and the SSC device depicts a specific capacity of 439 mAh/g. These electrode materials are indispensable for creating flexible, lightweight, asymmetric supercapacitor cells (ASC). In an ideal scenario, these nanostructured, high-performance, material-based ASC devices can conduit the breach between conventional capacitors and batteries.

Keywords:

Biowaste, activated porous carbon, EDLC, Pseudo capacitance, Transition metal oxide composite, Metal sulfide composite, Asymmetric supercapacitor, Symmetric supercapacitor, Conducting polymer, PANI, Ppy, Ionic liquid, Pouch cell hybrid supercapacitor, Energy density, Power density, long cycle stability.